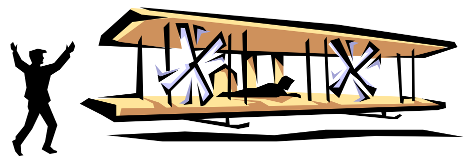
WrightSim

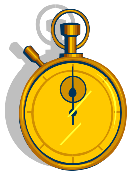


EDUCATIONAL ACTIVITIES

(For Grades 6 – 9)

Teacher Info

ROGER STORM
NASA Glenn Research Center
2004



ACTIVITY 1 – TEACHER PAGE "HOW FAST WERE YOU FLYING? "

OBJECTIVES

The student will
1. Relate distance traveled and time
2. Recognize the graph produced as a straight line.
3. Be able to convert from feet/second to miles/hour

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8

TEACHING STANDARD A: Teachers of science plan an inquiry-based science program for their students.
TEACHING STANDARD B: Teachers of science guide and facilitate learning.
CONTENT STANDARD A: Science as Inquiry
CONTENT STANDARD B: Physical Science As a result of their activities in grades 5-8, all students should develop an understanding of motions and forces

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL MATHEMATICS STANDARDS 5-8

STANDARD 1: Mathematics as problem solving
STANDARD 8: Patterns and functions
STANDARD 10: Statistics
STANDARD 13: Measurement

DESCRIPTION

The students will collect data from trial flights of the Wright Flyer. They will graph time aloft versus distance flown and then calculate average feet per second. Finally they will convert to miles per hour and compare this to known speeds.

TIME REQUIREMENTS

20 minutes for data collection
40 minutes for graphing and calculating

MATERIALS

Pencil, graph paper, ruler, and calculator

PROCEDURES

Each student should take three flights on the WrightSim program
Flight data from each student should be recorded and posted on the chalkboard.

BACKGROUND INFORMATION

In the famous first flight of December 17th, 1903, Orville Wright traveled a distance of 120 feet in 12 seconds. The time was estimated as he forgot to start the stopwatch. This speed is equivalent to 6.8 miles per hour. The top speed for a human is 27.89 miles per hour and even a house mouse can get up to 8 miles per hour. The ground speed of the Wright Flyer was pretty slow.

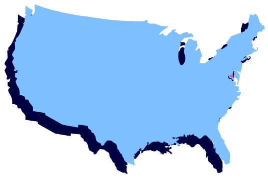
ANSWERS

6. **Yes** The graph should have a **line going up from left to right.**
7. As time increases, distance **increases**.
9. The units that are left are **miles and hours**
10. **17 mph**
11. The student's own average times 60 times 60 divided by 5280

12. **No**, it is not a fast speed.
13. **Yes** they can
14. **18 mph**

ASSESSMENT ACTIVITY

Check student answers against the teacher calculated class average.



ACTIVITY 2 – TEACHER PAGE
"WHERE WERE YOU FLYING? "

OBJECTIVES
The student will
1. Select appropriate features for safe gliding.
2. Identify hazards unfavorable to gliding.
3. Locate points on a map.

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8
CONTENT STANDARD B: Physical Science As a result of their activities in grades 5-8, all students should develop an understanding of motions and forces.
CONTENT STANDARD F: Science in Personal and Social Perspectives As a result of their activities in grades 5-8, all students should develop an understanding of natural hazards as well as risks and benefits
CONTENT STANDARD G: History and Nature of Science As a result of their activities in grades 5-8, all students should develop an understanding of history of science

DESCRIPTION
The students will examine the topography of several locations and discuss the reasons as to why and why not they would be suitable places to test the 1903 Wright Flyer. They will also use a map to mark the locations of Dayton, Ohio and Kitty Hawk, North Carolina.

TIME REQUIREMENTS
30 minutes

MATERIALS
Pencil, United Stated map or atlas that would show Dayton and Kitty Hawk, and student worksheets

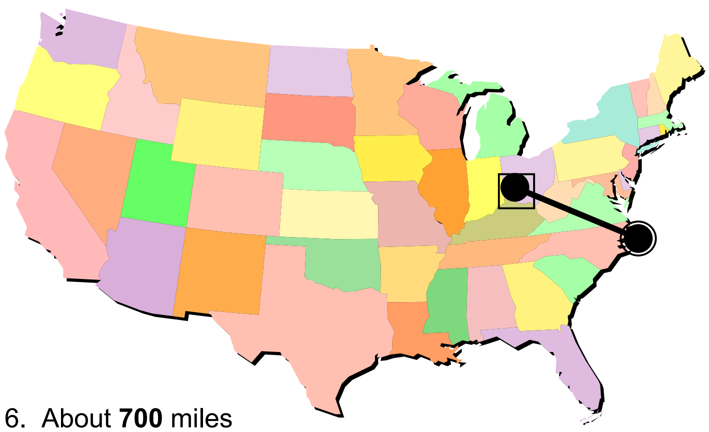
PROCEDURES
Each student should have taken three flights on the WrightSim program.
Students should read the introductory material and then examine each of the locations pictured.
Based on what they should see as favorable conditions for gliding and flying, they should evaluate the positive and negative aspects of each location.
After this discussion the teacher should pass out page two of the activity and discuss what is seen in the Wright's pictures of Kitty Hawk. Then the students should complete the map activity. If a class does not have a map showing Dayton and Kitty Hawk, they are available on the internet at a number of sites such as http://www.mapsonus.com/. If students have access they can use one of the sites to find both location and distance.

BACKGROUND INFORMATION
In 1899, Wilbur Wright wrote to the National Weather Bureau for advice on locations around the country that had the highest average winds, knowing that winds were necessary to their intended gliding experiments. He received a personal reply from the chief of the Weather Bureau and information on the average hourly winds from all U.S. weather stations at the time. He chose Kitty Hawk on the Outer Banks of North Carolina because it had the highest average winds and wasn't too far from Dayton, Ohio. Upon further inquiry he discovered that there was much sand for soft landings, few trees, and some large hills to glide down.

ANSWERS (STUDENT RESPONSES MAY VARY. SOME EXAMPLES SHOWN BELOW)

	FAVORABLE	UNFAVORABLE
A	Lots of shade	Many trees to run into and to block wind
B	High cliffs for take-off	Dangerous heights Nowhere to land Swirling wind
C	Height to take-off from	Dangerous waterfall Trees to run into Nowhere to land
D	Open spaces Hills to launch from	Cactus to run into Lack of water
E	Open areas Hills to launch from	Buildings to hit Trees
F	Open areas Hills to launch from Soft sand No trees	Lack of water

Some responses, such as "Remote area" can qualify as both good because there would be fewer curious onlookers and bad because it would be hard to get supplies. The class discussion should center about making the best choice by balancing good and bad factors. Some things like a lack of water can be overcome while others like a waterfall cannot.



6. About **700** miles

7. The correct answers are **a. train** and **d. boat**

They took a train from Dayton to Hampton Roads, Virginia, then a ferry to Norfolk, Virginia, and then a train down to Elizabeth City, Virginia. From there they had to hire a boat to take them across the Albermarle Sound to the Outer Banks and Kitty Hawk.

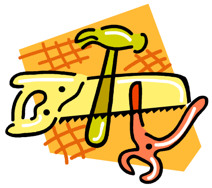
8. On average the trip took **d. 2-3 days**. The train took about 24 hours, but the boat trip depended upon weather and availability of a boat to hire. The first trip took Wilbur a week.

ASSESSMENT ACTIVITIES

Students should be able to defend the choices they made to the class. This may be done in a class discussion about suitable locations.

In the second part, students may point to a map in the room, is available. Otherwise, the teacher can check each student's answers.

The teacher could show the terrain in the simulation by using the joystick after a flight to zoom around or use the z and x keys to zoom in and out and the arrow keys to zoom around. This will show the terrain at Kitty Hawk, a sandy, narrow spit of land.



ACTIVITY 3 – TEACHER PAGE

“HOW WAS THE FLYER DESIGNED ?”

OBJECTIVES
The student will
1. Recognize the need to balance strength with lightweight construction
2. Identify similar structures in bridges.

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8:
CONTENT STANDARD E: Science and Technology As a result of their activities in grades 5-8, all students should develop abilities of technological design and understandings about science and technology

DESCRIPTION
The students will examine the open, lightweight structure of the Wright flyer as seen in the simulation and recognize the advantages of a light, strong design in an aircraft. They will also examine several types of bridge construction and make comparisons to the 1903 Wright flyer.

TIME REQUIREMENTS
30 minutes

MATERIALS
Pencil or pen, and student handout.

PROCEDURES
Each student should have taken three flights on the WrightSim program.

BACKGROUND INFORMATION
The Wright brothers did research before constructing their aircraft. Prior to 1900 a number of flight pioneers such as Otto Lilienthal and Octave Chanute had constructed manned gliders. Chanute, in particular, constructed box-trussed bi-wing gliders that he had tested on the Indiana Dunes in 1896. He was an engineer who constructed the first bridge over the Missouri River. This background certainly influenced his glider design.

Chanute is standing in the center on the bridge.

Far right: A Chanute glider.

The cloth over a thin wood frame was braced with wires and was very sturdy. The Wrights used this design but modified it to have moveable surfaces. Moving these surfaces gave them control over the direction of the aircraft. This was really their most important contribution to the invention of the airplane

ANSWERS (STUDENT RESPONSES MAY VARY. SOME EXAMPLES SHOWN BELOW)

2. Metal would be **too heavy** for their small engine.

6. The **truss bridge**

QUESTIONS SECTION:

1. Construction needs to be both **lightweight and strong**

2. These are **lightweight** materials

3. They were made in a biplane design and diagonally braced with wire. This made them light but strong.

4. **Truss bridges** are made this way. The wires on the airplane distribute the forces on the wing the same way trusses distribute the forces on the bridge.

ASSESSMENT ACTIVITIES

Students should discuss their answers to the Questions section.

ACTIVITY 4 – TEACHER PAGE

"THE NEED FOR INSTRUMENTS "

OBJECTIVES
The student will:
1. Recognize the need to use instruments to collect data
2. Identify the instruments used by the Wright brothers and why they used them.

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8:
CONTENT STANDARD A: Science as Inquiry Use appropriate tools and techniques to gather, analyze, and interpret data
CONTENT STANDARD E: Science and Technology As a result of their activities in grades 5-8, all students should develop abilities of technological design and understandings about science and technology

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL MATHEMATICS STANDARDS 5-8
STANDARD 13: Measurement

DESCRIPTION
The students will examine some of the instruments used by the Wright brothers in their flight experiments. They should identify the function of the instruments and discuss their reliability and accuracy.

TIME REQUIREMENTS
40 minutes

MATERIALS
Pencil or pen, and student handout.

PROCEDURES
Each student should have taken three flights on the WrightSim program.
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BACKGROUND INFORMATION
The Wright brothers did research and recorded data on almost every flight and glide they made, particularly time, distance, wind speed, and angle of descent They also measured the power of their engines and propellers, lift on wing shapes, drag on wing shapes, and the weight of their aircraft. They then made graphs of their data to determine optimal conditions. It was through analysis of the data from their instruments that they eventually unlocked the secrets of flight. They used their camera to document their experiments. Theirs was to the first invention to be documented by photographs.

ANSWERS (STUDENT RESPONSES MAY VARY. SOME EXAMPLES SHOWN BELOW)

1. Speed, amount of fuel, temperature of the engine, time, etc.

2. 40 yards in 12 seconds is **not very fast**. Football players do 40 yards in 4-5 seconds.

3. (Student guess) Anemometers measure the **speed of the wind**.

5. Student answers will vary.
   Yardstick is more accurate since it is longer it will be moved less and so less chance to make an error.

6. You would have to know the **length of one pace** or step.
   For the knotted rope you would have to know the **number of knots and the distance between each** knot
   The **knotted rope** would probably be more accurate because each of your paces may not be exactly the same.

7. **1445** inches ($2 \times 3.14 \times 1 \times 230$) ; **120** feet ($1445 \div 12$) ; **First** flight

8. Student answers will vary. A photographic record would prove to others that they had flown. It would also give them a record of how their aircraft looked in the air.

   Student answers will vary. The rubber bulb operated the shutter.

Questions Section:

1. It is hard to compare your results and draw accurate or meaningful conclusions.

2. A **stopwatch to measure the time** of each flight and an **anemometer to find wind speed**.

3. At the airport and at the weather bureau.

4. They took pictures to have **a visual record** of their flights and to prove they had flown.

5. Today computers can be used to alter pictures.

ASSESSMENT ACTIVITIES

Students should discuss their answers to the Questions section.

ACTIVITY 5 – TEACHER PAGE

"PITCH HAS ITS UPS AND DOWNS"

OBJECTIVES
The student will:
1. Understand how angle of attack (pitch) affects lift
2. Predict the outcome of various angles of attack on the Wright elevator.

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8:
CONTENT STANDARD A: Science as Inquiry Use appropriate tools and techniques to gather, analyze, and interpret data.
CONTENT STANDARD B: Physical Science As a result of their activities in grades 5-8, all students should develop and understanding of motions and forces and transfer of energy.
CONTENT STANDARD E: Science and Technology As a result of their activities in grades 5-8, all students should develop abilities of technological design and understandings about science and technology.

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL MATHEMATICS STANDARDS 5-8
STANDARD 13: Measurement

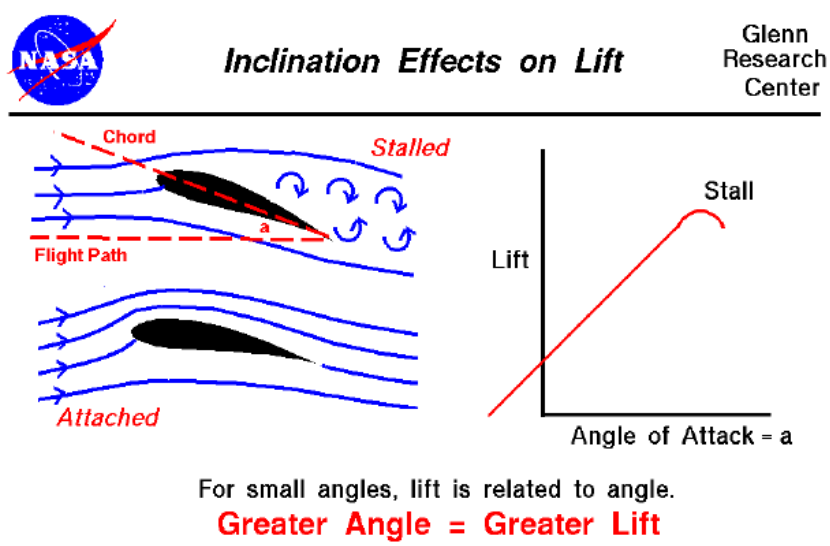
DESCRIPTION
The students will examine the effect on lift caused by the angle of attack of a wing. They will do both a hands-on activity as well as an on-line simulation.

TIME REQUIREMENTS
40 minutes

MATERIALS
Pencil or pen, and student handout.
Fan (Square, "breeze box" fan works best)
Flat pieces of cardboard, approximately one to two feet square
-unopened file folders could be used, but they are not as stiff . It would be best to glue them together in stacks of three or four.
Computer with internet access

PROCEDURES
Each student should have taken three flights on the WrightSim program.
Groups can take turns at the fan.
An art activity can be integrated by having students decorate their cardboard squares with airplane themes.

BACKGROUND INFORMATION
The angle of attack is the angle between horizontal flight and the "chord" which runs through the centerline of the airfoil. This angle is proportional to the amount of lift generated up to a maximum angle, and then the amount of lift falls off rapidly and the aircraft stalls. The Wright brothers had to constantly adjust their



elevator to stay in the air. The key was to get into the air and then try only to make small adjustments. The first attempt to fly in 1903 was by Wilbur on December 14th (He won the coin toss). He pulled back on the elevator control too sharply, the elevator soon began to lose lift, and he crashed into the sand after only three seconds in the air. Generally students attempting to fly “WrightSim” for the first time have the same problem. They set too high an angle of attack on the elevator and when it stalls they overcorrect. This deadly combination means very short flights. This 1903 aircraft was inherently unstable and takes very keen piloting skills. It is doubtful that too many students achieve any success in just three attempts. After doing this activity, however, it is hoped that they can improve their skills increase their flying distance by noting the effects of the elevator.

ANSWERS (STUDENT RESPONSES MAY VARY. SOME EXAMPLES SHOWN BELOW)

2. If the front edge is up the cardboard is forced **up**.

   If the front edge is down the cardboard is forced **down**.

   If the front edge is turned right the cardboard is forced **right**.

   If the front edge is turned left the cardboard is forced **left**.

INTERNET ACTIVITY

a) **566 lbs** b) **874 lbs** c) **1028 lbs** d) **733 lbs** e) **–374 lbs** f) **3.95 degrees**

g) the maximum lift is **from 14.33 to 14.9 degrees** h) you begin to lose lift at **14.93 degrees**

QUESTIONS SECTION:

1. A wing creates a force by **turning** air.

2. The angle at which the wing meets the air is called the angle of **attack**.

3. When a wing turns air, a force in an upward direction is generated. This force is called **lift**.

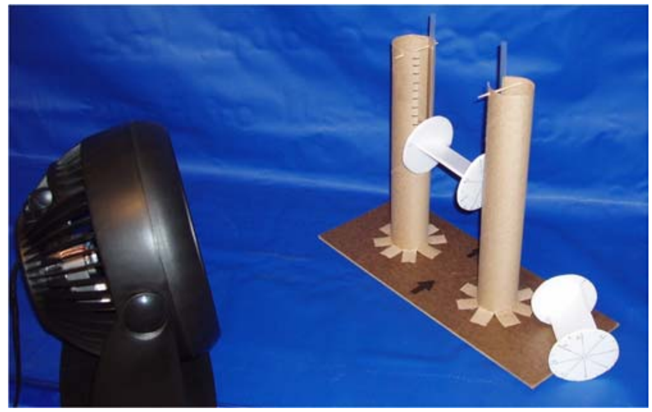
4. When the angle of attack becomes too steep the air flow separates from the top of the wing, lift is lost, and the aircraft stalls.

5. The up or down movement of the nose of an aircraft is called **B) pitch.**

6. The part of the aircraft that causes the up and down movement of the nose is called the **elevator**.

ASSESSMENT ACTIVITIES

Students should discuss their answers to the Questions section.



ACTIVITY 6 – TEACHER PAGE

"MAKING A TEST STAND "

OBJECTIVES
The student will:
1. Construct a "test stand" and test wing sections
2. Investigate how angle of attack (pitch) affects lift
3. Predict the outcome of various angles of attack on the Wright elevator.

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8:
TEACHING STANDARD A: Teachers of science plan an inquiry-based science program for their students.
CONTENT STANDARD A: Science as Inquiry Use appropriate tools and techniques to gather, analyze, and interpret data.
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THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL MATHEMATICS STANDARDS 5-8
STANDARD 13: Measurement

DESCRIPTION
Students will construct a device that allows them to investigate the effect on lift of different angles of attack.

An additional activity investigating lift can be found at:

http://quest.arc.nasa.gov/aero/wright/teachers/angles/lift_and_angle_of_attack.html

TIME REQUIREMENTS
Construct Tower – 25 minutes
Construct test airfoil – 25 minutes
Testing airfoil – 15 minutes

MATERIALS
2 – Paper towel cardboard tubes or a Christmas wrap tube
Fan (Square, "breeze box" fan works best)
Flat piece of wood, approximately 6 by 12 inches
Low temperature glue gun
Styrofoam meat tray (unused) from the supermarket
Exacto knife
Scissors
Protractor
4 Quilting pins (small plastic bead on top)
Straight edge
Pen
Optional: Cardboard box and cardboard strips to make a flow straightener

PROCEDURES

Each student should have taken three flights on the WrightSim program.

The teacher can make the testing tower whiled the students just construct the airfoils to be tested. Two testing towers can use the same fan. The time estimate is based on six teacher made towers operating at three fans for a class of 24.

. Groups can take turns at the fan. Cutting with an exacto knife can be dangerous and ought to be done on scrap cardboard, not on a desk or table.

Follow the procedure in the student section.

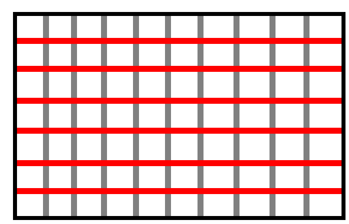
Results are mostly qualitative and class data ought to be compared.

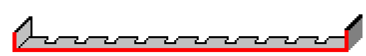
BACKGROUND INFORMATION

The angle of attack is the angle between horizontal flight and the "chord" which runs through the centerline of the airfoil. This angle is proportional to the amount of lift generated up to a maximum angle, and then the amount of lift falls off rapidly and the aircraft stalls. The Wright brothers had to constantly adjust their elevator to stay in the air. The key was to get into the air and then try only to make small adjustments. The first attempt to fly in 1903 was by Wilbur on December 14th (He won the coin toss). He pulled back on the elevator control too sharply and the elevator soon began to lose lift and he crashed into the sand after only three seconds in the air. Generally students attempting to fly "WrightSim" for the first time have the same problem. They set too high an angle of attack for the elevator and then overcorrect when it stalls. This deadly combination means very short flights. This 1903 aircraft was inherently unstable and takes very keen piloting skills. It is doubtful that too many students achieve any success in just three attempts. After doing this activity, however, it is hoped that they can improve their skills increase their flying distance by noting the effects of the elevator.

The size of the fan and the distance between the fan and the testing tower will influence the results. The teacher should set up conditions such that a 10 or so degree angle will float about half-way up the test slot. You may have to change the distance from the fan and/or the fan speed. This will take some practice ahead of time. Otherwise, the test airfoil may not lift at all or may lift right out of the tube. Also, the fan will cause the air to swirl so that there will be difference in some positions that are the same distance from the fan. If the air swirls too much you might want to make a flow straightener which can be done as follows:

Obtain a cardboard box about the size of your fan. The depth of the box does not matter. Measure the length and width and then divide each by two to determine the number of slats to make. If the box were 12 by 18 inches, you would need 15 slats, 9 at 14" and 6 at 20". The length of the slats allows you to fold up one inch at each end. To make the slate interlock, cut grooves half-way through, nine on the long slats and 6 on the shorter slate. (Your number of slats and slots may vary depending on the size of the box used.) Interlock all the slats into a grid and then tape the folded ends to the inside of the box.





ANSWERS (STUDENT RESPONSES MAY VARY. SOME EXAMPLES SHOWN BELOW)

CHART: There should be lift at 5º, 10º 15º, 20º, 30º, and maybe 45º. There should be no lift at 0º and 90º. There should be a downward force at -10º.

1. Answers vary, but generally an angle somewhere **from 5º to 30º** gives the greatest lift.

2. **0º and 90º** (and maybe 45º) gave no lift.

3. The lift **decreases**.

4. It usually **crashed**. This was because the **angle on the elevator got too high** and the elevator lost lift so the plane went down.

5. I learned not pull back not the stick so much. The elevator will need a shallow angle, like maybe 5º or 10º or else the Flyer will stall and crash.

6. The force is **downward**. The spoiler would also make **a downward force**.

7. A downward force would keep the **wheels pushed down** onto the track for more traction.

Extra Credit. The streamlined shape of the race car causes it to generate lift and thus pick up the back wheels. Because of its negative angle of attack, the spoiler “spoils” this lift by generating a downward force to keep the car from becoming airborne and to keep the wheels pushed down onto the track.

<u>ASSESSMENT ACTIVITIES</u>

-Students should discuss their answers to the Questions section.

- Students should get a second try to pilot the 1903 Flyer and having done this exercise they should try to be careful with the angle of attack upon the elevator. It might be good to have them record their results the second three tries to compare to the first three. Again, because the 1903 Flyer is difficult to fly, don’t let them be discouraged if they fail to do better. Some people will improve and these successes should be the focus.

ACTIVITY 7 – TEACHER PAGE

"USE THE WRIGHT LEVER"

OBJECTIVES
The student will:
1. Understand how a second class lever works
2. Understand mechanical advantage

THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL SCIENCE STANDARDS 5-8:
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THIS ACTIVITY SUPPORTS THE FOLLOWING NATIONAL MATHEMATICS STANDARDS 5-8
STANDARD 1: Mathematics as Problem Solving
STANDARD 7: Computation

DESCRIPTION
In this activity the students examine the elevator control lever of the 1903 Wright Flyer and are introduced to the three different classes of levers. The relationships between effort, load, and distance from the fulcrum are discussed.

TIME REQUIREMENTS
40 minutes

MATERIALS
pencil or pen
student handout
calculator

PROCEDURES
Each student should have taken three flights on the WrightSim program before working through this activity.

BACKGROUND INFORMATION
Levers can be used to change the direction of a force as well as to multiply a force or increase a distance. First class levers, like a see-saw, always change the direction of a force. The ration between the effort distance from the fulcrum and the load distance is called the Mechanical Advantage. It an effort force is applied 8 feet from a fulcrum to a load that is just 2 feet from the fulcrum, then the Mechanical Advantage is $8 \div 2 = 4$. Therefore, a 10 pound effort can lift a 40 pound load. The distance moved, however, is the inverse of the Mechanical Advantage. For a 10 pound effort to lift a 40 pound load, the effort must move 4 feet for every one foot the load would move. If effort is decreased, then distance is increased.

A second class lever also multiplies the amount of effort applied, but both the effort and the load move in the same direction. The load is between the effort and the fulcrum.

A third class lever has the effort between the fulcrum and the load, so both effort and load move in the same direction as in the second class lever, but the effort now must be larger than the load (the Mechanical Advantage will be less than one). The reason to use this lever is that a small movement in the effort causes a larger movement in the load. A first class lever can do the same thing if the effort is closer to the fulcrum than the load.

ANSWERS

4. The elevator control arm is a **SECOND** class lever. **A) greater than the effort**

QUESTIONS SECTION ANSWERS:

1. There are **THREE** classes of levers.

2. The longer the lever, the **LESS** the effort needed to move the load.

3. The effort times the effort arm length always equals the **LOAD TIMES THE LOAD ARM LENGTH.**

4. 500 times 4 equals 2000 therefore 25 times __**X**__ must also equal 2000
   Solve for **X** **X** = 2000 ÷ 25 **X = 40 feet**

5. 300 times 4 equals 1200 therefore __**X**__ times 12 must also equal 1200
   Solve for **X** **X** = 1200 ÷ 12 **X = 100 pounds**

6. This is a **SECOND CLASS** lever.

7. Since effort arm is 24 ÷ 2 = 12 times longer than the load arm, the load will only move one twelfth as much.
   6 inches times 1/12 equals **0.5 inches**

ASSESSMENT ACTIVITIES

Students should discuss their answers to the Questions section.